

AIR FORCE QUALIFICATION TRAINING PACKAGE (AFQTP)



**FOR
HEATING, VENTILATION, AIR
CONDITIONING/REFRIGERATION (HVAC/R)
(3E1X1)**

**MODULE 19
BURNERS**

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Career Field Education and Training Plan (CFETP) references from 1 July 2002 version.

OPR: HQ AFCESA/CEOF
(SMSgt Dan Sacks)
Supersedes AFQTP 3E1X1-19, 30 Jun 00

Certified by: HQ AFCESA/CEOF
(CMSgt Myrl F. Kibbe)
Pages: 14/Distribution F

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FOR
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INTRODUCTION

Before starting this AFQTP, refer to and read the “[AFQTP TRAINER/TRAINEE GUIDE](#).”

AFQTPs are mandatory and must be completed to fulfill task knowledge requirements on core and diamond tasks for upgrade training. ***It is important for the trainer and trainee to understand*** that an AFQTP ***does not*** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks.

MANDATORY minimum upgrade requirements:

Core task:

AFQTP completion
Hands-on certification

Diamond task:

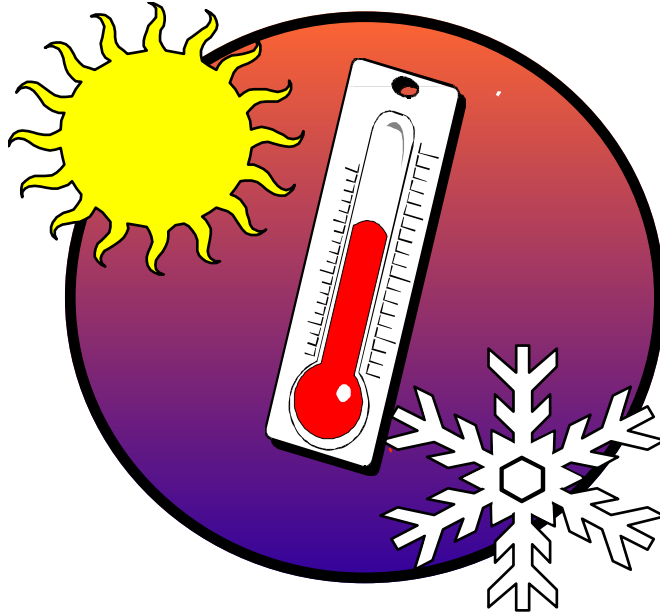
AFQTP completion
CerTest completion (80% minimum to pass)

Note: Trainees will receive hands-on certification training for Diamond Tasks when equipment becomes available either at home station or at a TDY location.

Put this package to use. Subject matter experts, under the direction and guidance of HQ AFCESA/CEOF, revised this AFQTP. If you have any recommendations for improving this document, please contact the HVAC/R Career Field Manager at the address below.

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BURNERS

MODULE 19

AFQTP UNIT 8

ADJUST FUEL/AIR RATIO FOR PROPER COMBUSTION EFFICIENCY (19.8.)

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ADJUST FUEL/AIR RATIO FOR PROPER COMBUSTION EFFICIENCY

Task Training Guide

STS Reference Number/Title:	19.8. - Adjust fuel/air ratio for proper combustion efficiency.
Training References:	<ol style="list-style-type: none"> 1. ASHRAE Handbook, 1988 Equipment. 2. William's Learning Network Interactive CD-ROM Version 2.0, Boiler: <i>Combustion, Water, and Steam</i>. 3. Career Development Course (CDC) HVAC/R Journeyman 3E151E, Volume 1, Unit 5, Section 5-3: <i>Combustion Efficiency</i>.
Prerequisites:	<ol style="list-style-type: none"> 1. Possess a minimum of a 3E131 AFSC. 2. Review the following references: <ol style="list-style-type: none"> 2.1. Boiler: Combustion, Water, and Steam CD-ROM. 2.2. Review Local and State Regulations. 3. Complete CDC HVAC/R Journeyman 3E151E, Volume1, Unit 5, Section 5-3.
Equipment/Tools Required:	<ol style="list-style-type: none"> 1. HVAC/R tool bag. 2. Personal safety equipment. 3. Gloves. 4. Manufacturer's cut sheet (if applicable).
Learning Objective:	The trainee will perform the steps to adjust fuel/air ratio for proper combustion efficiency.
Samples of Behavior:	Trainee will adjust fuel/air ratio for proper combustion efficiency.
Notes:	
<ol style="list-style-type: none"> 1. To successfully complete this element follow the steps outlined in the applicable technical manual, manufactures manual or local procedures. 2. Any safety violation is an automatic failure. 	

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ADJUST FUEL/AIR RATIO FOR PROPER COMBUSTION EFFICIENCY

1. Background. There have been many changes over the years. Environmental Protection Agency (EPA) regulations for refrigerant handling, hazardous material tracking, and many other areas have been tightened down to ensure mission readiness. In addition, there's a joint effort around the world to keep our environment healthy. As an Air Force member, it is your job to help the environment and follow the regulations set in place to accomplish this environmental task. In this lesson we will cover combustion efficiency, and how to obtain the proper efficiency. Other than protecting the environment, there are many other reasons HVAC/R technicians should maintain burner efficiency. Higher consumption of fuel, damage to equipment, and increased man-hours are just a few symptomatic areas to be concerned about. Higher efficiency burners increase capacity, which increases the ability to provide more heat at a lower cost.

1.1. By now you should have a clear understanding of construction features and operating principles of burners (oil and gas). The CDCs cover this area in detail. Also, do not confuse adjusting oil fire/gas flame with burner efficiency; there are many more factors involved. To take a snap shot of the big picture, correlation between burner heat loss (heat lost up the flue stack) and carbon dioxide (CO₂) percent are the determining factors when dealing with combustion efficiency.

1.2. As previously mentioned, this lesson will pinpoint areas concerning how to check and adjust for combustion efficiency. To successfully complete all of the steps, you will be required to use knowledge learned from prior tasks. To name a few, you will have to know how to adjust fuel pressure, primary/secondary air, and use combustion analyzers. Refer to CDC 3E151E, Volume 1, *Fuels and Fuel Burning Equipment*, if you need to brush up or find information.

2. Adjust fuel/air ratio for proper combustion efficiency. Combustion efficiency is the ratio of the useful heat (measured in BTUs) delivered by the burning fuel compared to the supply of fuel. The most efficient combustion will release the greatest amount of "useable" heat from fuel. Useable heat is heat that is *available* or BTUs that is *available* for heating the boiler or furnace.

2.1. Combustion Efficiency charts may be used to determine the combustion efficiency when burning more common fuels. As a condensed guideline, Figure 5-8 and 5-9 in CDC 3E151E, Volume 1, depicts an efficiency chart. When you are using these charts, it is necessary to know the percentage of the CO₂ in the flue gas, the temperature of the flue gas, the boiler room temperature (burner intake), and the type of fuel being used. Table 5-2 in CDC 3E151E, Volume 1, shows another helpful tool. By using this table the technician can compare actual CO₂ with Ultimate Percent CO₂ for a specific type of fuel. If heat loss and percent CO₂ are the determining factors for efficiency, how do we calculate these values?

2.1.1. Of the many types of heat loss, we are going to focus on losses that go up the chimney. When excessive heat goes up the stack, actual useable BTUs are taken away from the burner. The causes of this type of heat loss can be confined to excess air loss, unburned fuel (smoke), and excess flue-gas temperature.

2.1.1.1. Excess air is used to ensure complete combustion. Too much excess air will increase heat loss thereby decreasing efficiency. Refer to your CDCs for any additional information on this subject.

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2.1.1.2. Unburned fuel (smoke) is another undesirable factor concerning efficiency. As far as stack heat loss, this second factor is not as critical as the other two. Heavy smoking will only add 4 to 5 percent to the total heat loss. However, smoking is very critical when it comes to maintenance, thermal insulation, environment, and health of personnel. Thick layers of soot will form on burner parts and drastically decrease efficiency.

2.1.1.3. Excess flue-gas temperature will encourage rapid heat loss through the stack. In fact, to perform a heat loss calculation you must physically acquire the flue gas temperature. As mentioned in the CDCs, to effectively check for burner efficiency, you must calculate the **net stack temperature**. Net stack temperature is the difference between **boiler room temperature** and actual **stack/flue temperature**. For example, let's say that the boiler room temp is 90° F and the stack temp is 440° F. The difference between the two variables is 350° F. This is your net stack temperature.

2.1.2. Now that we covered heat loss (chimney), CO₂ percentage is the second determining factor for combustion efficiency. There are many types CO₂ indicators available in today's market. The older versions require pumping action to force gas samples into a tube and newer models can instantaneously read CO₂ levels. Whichever type your shop has, be sure to follow the manufacturer's manual before taking readings.

2.2. With the two variables, net stack temp and percentage of CO₂, you can find your combustion efficiency. In figures 5-8 and 5-9 of CDC 3E151E, Volume 1, there are sample charts for finding total system heat loss. By finding this final heat loss value, you are actually finding combustion efficiency. As you can see, a higher CO₂ reading, and a lower stack temperature is desirable. For example, if your final value is 10%, this means the system has 10% heat loss through the stack. For additional help concerning this calculation, refer to the information in the CDCs pertaining to figures 5-8 and 5-9. The combustion efficiency slide rule calculator is another convenient tool for the HVAC/R technician. By setting the calculator to the actual net stack temp and actual CO₂ percentage, you can directly find burner combustion efficiency.

SAFETY:

ALWAYS KEEP SAFETY PROCEDURES IN MIND WHEN DEALING WITH FIRE OR FIRE PRODUCING EQUIPMENT. KEEP YOUR FACE AND HANDS AWAY FROM THE OPENING.

BURNERS ALSO CAN PRODUCE CARBON MONOXIDE. EFFECTS FROM THIS POISONOUS GAS ARE FATAL.

3. Procedures. Follow these steps to adjust fuel/air ratio for proper combustion efficiency, (refer to flow chart on page 19-9 for further clarification):

Step 1. Gather and read all manufacturers' information concerning specific burner equipment being checked.

Step 2. With a thermometer, find the flue-gas temperature and boiler room temperature. The difference is the actual net stack temperature.

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Step 3. Find the CO₂ percentage at the flue (same area as stack temperature reading) for the burner. Refer to the manufacturer's manual for your particular model.

Step 4. By using an efficiency slide ruler calculator or tables (for the specific type of fuel) contained in the CDCs find the actual combustion efficiency percentage. Use the values from steps 2 and 3 when finding this percentage. This is the actual percent of heat loss through the stack.

Step 5. If the exhaust temperature/ CO₂ ratio exceeds the manufacturer's recommended heat loss amount, go to step 6. If this amount is within the manufacturer's limitations, this task is now complete.

Step 6. Properly adjust fuel/air ratio to obtain CO₂ levels that are within the manufacturer's specifications for the fuel that you are using. Recheck CO₂ levels until properly adjusted.

SAFETY:

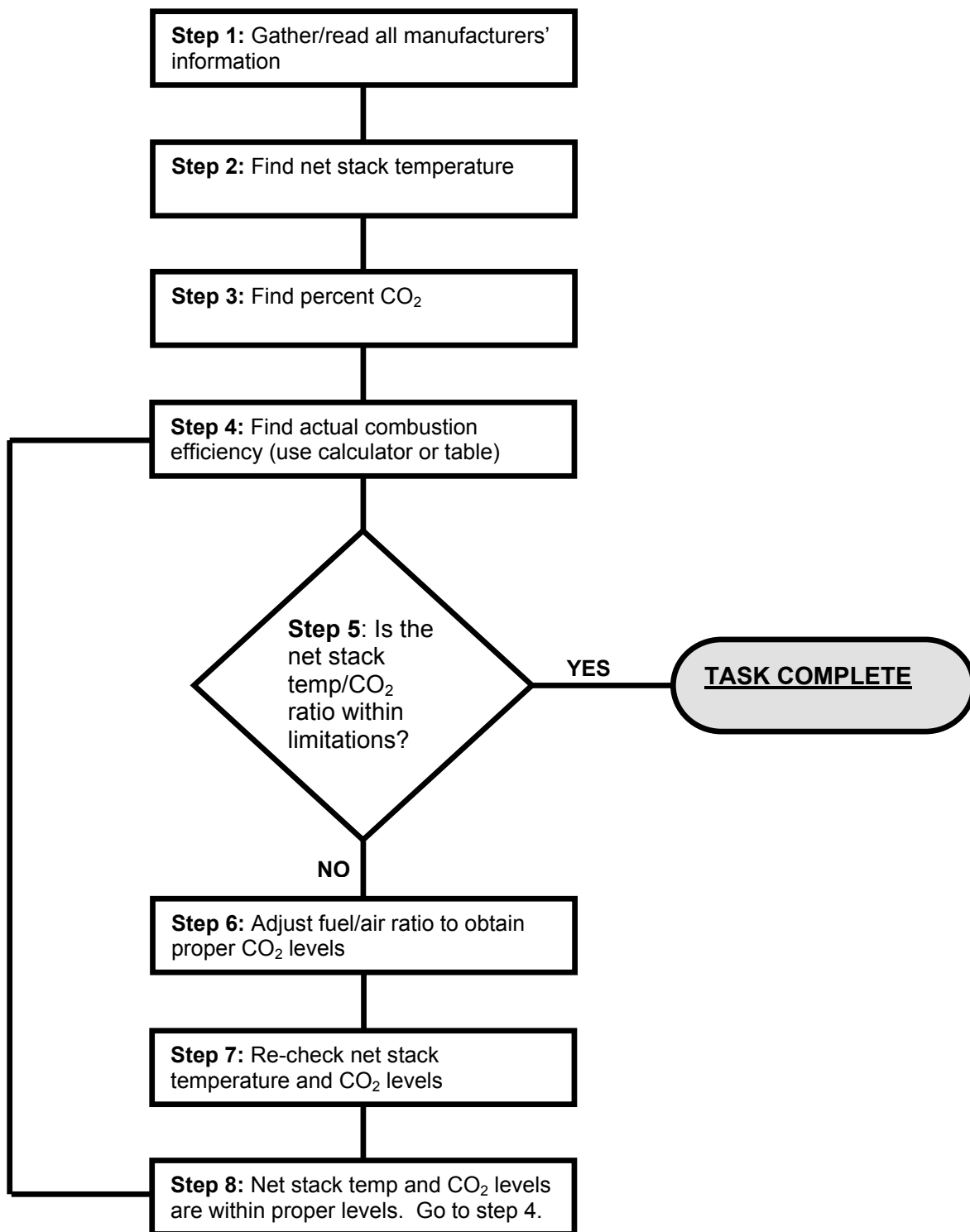
WHILE PERFORMING THE ADJUSTMENT, ENSURE THE EQUIPMENT IS NOT PRODUCING ANY CARBON MONOXIDE.

Step 7. Check the net stack temperature and CO₂ levels for the burner. Ensure that the burner does not have excessive chimney losses. Refer to manufacturer's manual for guidance.

Step 8. Once the CO₂ levels and stack temperatures are within expectable levels, re-accomplish steps 4 and 5.

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**ADJUST FUEL/AIR RATIO FOR PROPER COMBUSTION EFFICIENCY
FLOW CHART**



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**REVIEW QUESTIONS
FOR
ADJUST FUEL/AIR RATIO FOR PROPER COMBUSTION EFFICIENCY**

QUESTION	ANSWER
1. The two factors to find combustion efficiency are net stack temperature and CO ₂ percent.	a. True. b. False.
2. The most efficient combustion is that which releases the greatest amount of <u>useable</u> heat from the fuel.	a. True. b. False.
3. What is/are the factor(s) used to compute combustion efficiency?	a. The percentage of the CO ₂ in a flue gas. b. Stack temperature. c. The room temperature. d. All the above. e. B and C.
4. What are two out of the three causes of excessive chimney heat loss?	a. Excess air loss and excess fuel temp. b. Excess air loss and excess flue temp. c. Excess CO ₂ and excess fuel temp. d. Excess CO ₂ and excess flue temp.
5. Why is combustion efficiency important?	Written response.
6. All fuels burn at the same temperatures.	a. True. b. False.
7. What unit of measurement is used to measure the amount of potential energy?	a. Psi. b. Ratio. c. BTUs. d. Temperature.
8. A higher CO ₂ reading and a lower stack temperature are desirable.	a. True. b. False.

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ADJUST FUEL/AIR RATIO FOR PROPER COMBUSTION EFFICIENCY

PERFORMANCE CHECKLIST

INSTRUCTIONS:

The trainee must satisfactorily perform all parts of the task without assistance. Evaluate the trainee's performance using this checklist.

DID THE TRAINEE....	YES	NO
1. gather and read all information concerning burner equipment?		
2. measure flue gas and room temperature?		
3. properly calculate net stack temperature?		
4. find CO ₂ percentage for the burner?		
5. use slide ruler or table to find combustion efficiency?		
6. properly adjust fuel/air ratio within acceptable limits (if applicable)?		
7. comply with all safety requirements ?		

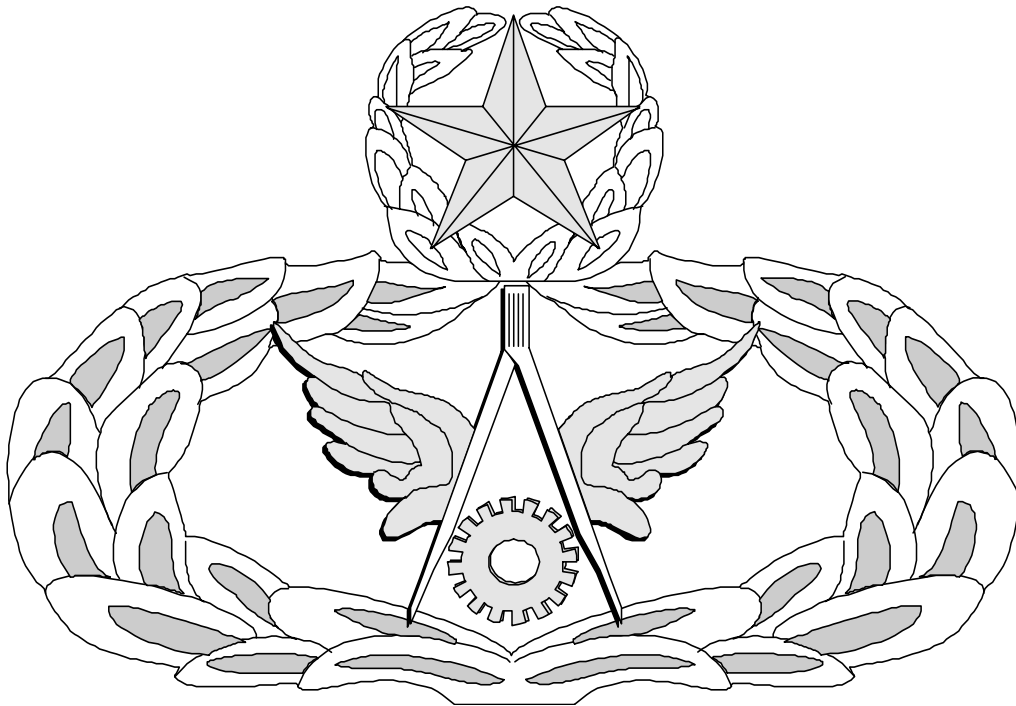
FEEDBACK: Trainer/Certifier should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer/certifier.

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Air Force Civil Engineer

QUALIFICATION TRAINING PACKAGE (QTP)

REVIEW ANSWER KEY



FOR
HEATING, VENTILATION, AIR
CONDITIONING/REFRIGERATION (HVAC/R)
(3E1X1)

MODULE 19

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Key-1

**ADJUST FUEL/AIR RATIO FOR PROPER COMBUSTION EFFICIENCY
(3E1X1-19.8.)**

QUESTION	ANSWER
1. The two factors to find combustion efficiency are net stack temperature and CO ₂ percent.	a. True.
2. The most efficient combustion is that which releases the greatest amount of <u>useable</u> heat from the fuel.	a. True.
3. What is/are the factor(s) used to compute combustion efficiency?	d. All the above.
4. What are two out of the three causes of excessive chimney heat loss?	b. Excess air loss and excess flue temp.
5. Why is combustion efficiency important?	Not only does it protect the environment, but higher efficiency burners increase capacity, which increases the ability to provide more heat at a lower cost.
6. All fuels burn at the same temperatures.	b. False.
7. What unit of measurement is used to measure the amount of potential energy?	c. BTUs.
8. A higher CO ₂ reading and a lower stack temperature are desirable.	a. True.

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MEMORANDUM FOR HQ AFCESA/CEOF
139 Barnes Drive Suite 1
Tyndall AFB, FL 32403-5319

FROM:

SUBJECT: Air Force Qualification Training Package Improvement

1. Identify module.

Module # and title _____

2. Identify improvement/correction section(s)

_____ STS Task Reference	_____ Performance Checklist
_____ Training Reference	_____ Feedback
_____ Evaluation Instructions	_____ Format
_____ Performance Resources	_____ Other
_____ Steps in Task Performance	

3. Recommended changes--use a continuation sheet if necessary.

4. You may choose to call in your recommendations to DSN 523-6445 or FAX DSN/Commercial 523-6488 or (850) 283-6488 or email ceof.helpdesk@tyndall.af.mil.

5. Thank you for your time and interest.

YOUR NAME, RANK, USAF
Title/Position